

Dr. Edward B. Hartshorne, Philadelphia, June 22, 1885, æt. 68.

Lieut. Henry H. Gorringer, New York, N. Y., July 6, 1885.

On motion the President was authorized at his discretion to appoint suitable persons to prepare the usual obituary notices.

The President reported that he had appointed Samuel Wagner, Esq., to prepare an obituary notice of the late Robert Treat Paine, and that Mr. Wagner had accepted the duty.

A paper by Prof. Daniel Kirkwood of Bloomington, Indiana, entitled "The Comet of 1866, and the Meteors of November 14th," was presented, for which a plate was authorized.

Pending nominations Nos. 1049-1068 were read.

On motion the Society ordered, subject to the approval of the Finance Committee, that a plate should be prepared to accompany Dr. Stokes' paper presented at the last meeting at a total cost not to exceed \$44.

On motion the Society resolved to dispense with the meetings of August 21st and September 18th, and with that of the Officers and Council on August 14th.

The rough minutes were read and the Society was adjourned by the President.

A great Trap Dyke across Southeastern Pennsylvania.

By Prof. H. Carvill Lewis.

(Read before the American Philosophical Society, May 15, 1885.)

Prof. H. D. Rogers, in his Report on the Geology of Pennsylvania, published in 1858, refers to two trap dykes in Southeastern Pennsylvania. One of these is said to cross the Bethlehem turnpike about a mile above Flourtown, being "about two and one-half miles long, commencing north-west of Springfield township and ranging past Bickell's Mill on the Wissahickon to the School-House further west." * The other dyke is described as follows: "Another dyke or trap crosses the Schuylkill near Conshohocken; commencing a little east of the Perkiomen turnpike, about half way between Barren Hill and Marble Hall, it crosses the Norristown or Ridge turnpike, ranges nearly along the crest of the Conshohocken

* Geol. of Penna., Rogers, Vol. I, p. 214, 1858.



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slate ridge, goes through the village, and passing the river, in the bed of which it may be seen, it follows the summit of Bethel hill into Delaware county, terminating near the road leading from the Lancaster turnpike to the King of Prussia village. This is by far the longest and widest trap dyke of the valley or its borders, its length being a little more than six miles."*

In the map published by the Second Geological Survey, under the direction of Prof. J. P. Lesley, Mr. C. E. Hall has connected the two dykes on Prof. Rogers' map to form a single dyke extending from the east of Flourtown in a west, south-westerly direction to the borders of Delaware county. In his report (C⁶), Mr. Hall refers to the dyke briefly in several places. He says (p. 19), that "it extends in a nearly straight line from the county line south-west of Mechanicsville, a short distance north of Gulf creek, to Flourtown in Springfield township. East of Flourtown it has not been traced continuously. There are exposures of loose blocks of trap, however, in several localities extending in a north-east direction from the last exposures of the main belt at Flourtown."

He gives, on p. 23, a map showing some isolated exposures of trap boulders in Upper Dublin township, which indicate the probable north-west continuation of the dyke.

He makes some apparently irreconcilable statements as to whether or not it occupies a line of fault or disturbance. Thus, while saying (p. 20), "The dyke does not seem to mark any line of disturbance. It may occupy a fissure crack, along which no lateral movement has taken place;" he says on p. 75: "This dyke, evidently located along the line of some disturbance, is undoubtedly the course of a fault or fracture. There is, however, no positive proof of any lateral movement."

Mr. Hall represents the dyke on the colored map accompanying his report as having a length of a fraction over eight miles.

In the present paper, which is the result of the personal observations of the writer, made during the past two years, it will be shown, that the dyke heretofore described is only a small portion of a long narrow dyke which passes almost entirely across the south-eastern corner of this State, from near Doylestown to Maryland, and which, taken together with some parallel dykes of similar nature and composition, north-east of Doylestown, forms a series of nearly continuous dykes some ninety miles in length.

It will be shown that a great fissure was made at the close of the Triassic period across the State, which fissure, filled by eruptive diabase, traverses strata of Laurentian, Cambrian, Silurian and Triassic age in an almost unbroken line, thus becoming an important feature in the geology of the State.

We shall follow it continuously from a fine exposure south of Doylestown along its south-west course through Bucks, Montgomery, Delaware and Chester counties, to the Maryland border, and shall demonstrate by a detailed list of its outcrops, that, although frequently represented only by

* Geol. of Penna., Rogers, Vol. 1, p. 214, 1858.

a line of loose weathered boulders, it is practically continuous along a line seventy miles in length.

It will be shown that in Bucks county, the dyke abuts against the south side of a great fault of several thousand feet upthrow, and upwards of twenty miles in length, and that, at a distance laterally of five miles, another long dyke of identical composition and structure, as proved both chemically and microscopically, abuts against the north side of the fault, continuing thence to the Delaware river. If not the same dyke laterally displaced, the two portions clearly belong to the same system, produced by a single cause.

The following description of the course of the dyke south-westward from the Neshaminy creek, near Doylestown, is supplemented by an accompanying map in which all the observed outcrops are plotted.

The dyke forms a very prominent hill at the north end of what is known as "Mundock ridge," at a point one mile south-east of the village of Bridgepoint. The Neshaminy creek flows at its base, and the trap forms a conspicuous hill, steep on the north side, from the top of which there is a view of Doylestown and vicinity. This is at the corner of Warminster, Doylestown and Warwick townships.

As nearly as can be ascertained the dyke is here about 100 feet wide. It is a fine grained diabase (dolerite), finely crystalline, and, as shown by the microscope, composed of lath-shaped crystals of plagioclase, enclosing irregular grains of augite and grains and crystals of magnetite. It rings like metal when struck, and covers the hillside with large fragments, generally well rounded by the process of concentric weathering, due to atmospheric influences, and often much rusted on the outside.

The dyke rises in the middle of the Triassic area, cutting through the upper Triassic shales. It is clearly therefore of late or Post-Triassic age.

The Triassic shales and sandstones, immediately adjacent to the dyke, are not altered by it. Yet, in the vicinity, northward from the dyke and about Bridgepoint, the shales are strongly baked and blackened, breaking with conchoidal fracture and ringing when struck. They somewhat resemble, when so altered, a black limestone.

These baked shales, however, cannot be proved to have any connection with the dyke, as will be more definitely shown when we consider the great fault against which the dyke here abuts. They seem to be, however, connected with the fault, since all along it, for many miles, these baked rocks occur, as if heat had been evolved during the faulting. On the other hand, no local metamorphic effects have as yet been observed anywhere along the sides of the dyke. The molten trap seems to have cooled too rapidly to produce such effects.

The dyke was followed from this point in a direction to west of south, and was noticed as it crosses each road in the eastern corner of Warrington township, passing a half mile east of Warrington P. O., forming the "Mundock ridge." In Bucks and Montgomery counties the term "mundock" is universally given to the trap. The trap runs at first nearly due

south, crossing the Little Neshaminy creek near the line between Warminster and Warrington townships, and in Warminster township gradually bending south-westward till it crosses the county line into *Montgomery county* a mile and a half west of Warminster P. O.

In Horsham township, Montgomery county, it passes through the upper part of the village of Horshamville, crossing the Doylestown pike at the tollgate. It crosses the Welsh road 100 ft. above the road leading from Horshamville to Jarrettown, here forming a sharp hill. It is traced continuously from here to Jarrettown, where it runs under the school-house and the Methodist Church. The ground is covered with boulders of trap, giving the impression that the dyke is wide at this point. It here forms a sharp hill, descending steeply to the north. A white Triassic sandstone outcrops south of the dyke, between Jarrettown and Dreshertown.

A road running south-west from Jarrettown keeps along the dyke, which for some miles forms a steep slope on its north side, and is readily recognized. It crosses Susquehanna avenue about 100 ft. north of the road from Jarrettown, and is conspicuous at the crossing of a small creek half a mile further south-west.

It is now approaching the edge of the Triassic formation, and in the course of half a mile enters the Lower Silurian limestone valley of White Marsh. "Mundock Hill," is a prominent feature on the Township Line road at the fork of the roads at the corner of Springfield, White Marsh and Upper Dublin townships. The fragments of trap are here sometimes five feet in length, and cover the side of the hill, extending down the Township Line road as far as Sandy run.

Thus far the dyke has been followed without break in its course. Just here, however, at the corner of the three townships, there appears to be a break of a few hundred feet, since no boulders of trap were noticed on the road immediately west of the North Pennsylvania Railroad near Sandy Run station. It may be that, the ground in the limestone valley now entered being highly cultivated, the boulders have been removed by man, and that the break is more apparent than real. For on the next road westward, Church road, the dyke is clearly shown by numerous boulders at the junction of the road to Flourtown.

The dyke has now entered the Lower Silurian (Calcareous, Chazy and Trenton) limestones of White Marsh valley, and cuts through them successively without any apparent alteration either in the dip or in the character of the limestones. No evidence that the dyke was a line of fault could be detected. The trap dyke continues across Springfield township through Flourtown, as observed by Prof. Rogers and Mr. Hall, to the Wissahickon creek, which it crosses at a point one-half mile north of the Philadelphia county line. It here outcrops as a distinct wall sharply rising out of the soil. It crosses a field in the stock farm recently owned by A. Welch, and is well marked on the creek. It here offers an instructive example of a typical dyke. From here to Marble Hall, where there is probably a small "jog" in its course, it is well marked as a line of

boulders. It appears near the marble quarry, and trends across White Marsh township in a straight line in a west south-west direction toward Spring Mill, being recognized by its boulders at each road crossed.

These boulders, where not washed by streams, are decomposed on the surface, and are continually becoming smaller as time goes on. On high ground, where the soil is much decomposed, the dyke is only traceable with difficulty. On the hill east of Spring Mill, half a mile from the Schuylkill river, where numerous trap boulders, covered by a crust of soft brown oxidized material, occur on the roadside, large numbers of them were observed to be covered with peculiar markings or striae. The soft crust was marked by grooves each nearly a quarter of an inch in depth, and running from the angular edges of the boulders in somewhat parallel directions, one set of scratches often crossing another. Two rude sketches of these curious markings are here given, having been taken by the author in the Spring of 1879 :



These markings, which are common on fine grained ferruginous trap, and may be a foot or more in length, have been mistaken for glacial striae by several writers. Thus one writer,* after describing the scoring and scratching of the boulders in Warrington township, Bucks county, says that they "evidently mark the progress of a glacier, and cannot otherwise be accounted for." Similar mistakes have been made in Chester county.† Even such a well known geologist as Rev. H. W. Crosskey, LL.D., F.G.S.,‡ of Birmingham, has described and figured markings of this character in decomposed trap boulders in Worcestershire, England, as true glacial striae. The excellent plates and the detailed description he has published, show the markings to be identical with those on the trap now under description, which are quite different from true glacial striae. In fact, they are, in all probability, *plough marks*. They are precisely such as would be formed by the sharp point of a plough passing over the decomposed surface of a trap boulder. As would be expected, they generally occur only on one side of any boulder, the side uppermost, when ploughing was going on. As shown by the author, in his report on the Terminal Moraine§, and more particularly in a recent paper,|| they are far south of the limits of glaciation.

* History of Bucks County. Davis, p. 438.

† History of Chester County. Smith and Futhy, p. 186.

‡ The Grooved Blocks and Boulder clays of Rowley Hill. Proc. Birm. Philos. Soc., Vol. iii, 1882, p. 459.

§ Report Second Geolog. Survey of Pennsylvania, Z.

|| On Supposed Glaciation in Pennsylvania, south of the Terminal Moraine. Lewis. Amer. Journ. Science, Arts, xxviii, 1884, p. 276.

An interesting exposure of the trap in place was noticed at a short distance north of the spring, at Spring Mill, where the dyke is cut through by the creek. This is the only locality in Pennsylvania where the author has observed *basaltic* or *columnar structure* in this dyke. Large columns of trap lie here, nearly horizontally, several of them showing six sides, and one of them five feet in diameter. Their nearly horizontal position is, of course, due to the fact, that the columns lie at right angles to the cooling surfaces. As the cooling surfaces are here nearly perpendicular, the columns have taken a horizontal position. The columns appear to have an inclination of about eight degrees to the horizon, indicating, perhaps, that the dyke varies that much from the perpendicular. Although columnar structure has not been noticed elsewhere in this dyke, another structure characteristic of eruptive rocks is seen everywhere along the whole line. *Concretionary* structure, which, sometimes associated with columnar structure, but oftener observed alone, is due to the same contraction of the cooling mass, which sometimes forms columns, is a very common feature of the dyke. Though not apparent in the fresh rock, this structure is readily seen during the process of weathering, producing, finally, the rounded boulders that have already been described.

At Conshohocken, the dyke is finely exposed in the town and forms a conspicuous escarpment on the river bank, well seen from the railroad. At the time that the new Schuylkill Valley Railroad was being built, much was said about the difficulty experienced by the contractors in cutting through this remarkably tough rock at Conshohocken.

Crossing the Schuylkill, in the bed of which it is seen, as described by Professor Rogers, and being well shown on the west side of the river where cut through by the Philadelphia and Reading Railroad in West Conshohocken, the dyke follows a long straight line through Lower Merion township, Montgomery county, as mapped in Report C⁶, Second Geological Survey. It is well shown near Mechanicsville, where cut through by Gulf creek. In this portion of its course the dyke either cuts through or runs along the southern boundary of the hydromica schists (Hudson River Age?) of the South Valley hill. A few hundred feet west of Mechanicsville, it is in contact with highly metamorphic limestone, a continuation of that which occurs in Cream valley.

Immediately west of here, at the head waters of Gulf creek, it is in contact with what appears to be lower Cambrian sandstone, here highly altered into a slaty rock ringing like metal when struck. The strata stand nearly perpendicular with a steep north dip, and are much altered. The metamorphism is believed by the author to be of much more ancient date than the time of the eruption of this trap.

After crossing the stream, it enters *Delaware county*, Radnor township, and crosses the Pennsylvania Railroad at a point about a quarter of a mile west of Wayne station (at mile-post 15-338). Numerous loose boulders occurred here in the soil, but have recently been removed for railroad ballast.

It is here in contact with "Edgehill Rock" (altered Potsdam). Ancient eruptive norite rocks occur at Wayne station, and the trap lies between these older rocks (generally supposed to be Laurentian) and the hydromica schists of the South Valley hill, which are entered by the railroad west of here.

The dyke enters Chester county in Easttown township, south of Devon Inn, where it is in the so-called Laurentian area, and it is well shown at the cross-roads at the corners of Easttown, Tredyffrin, and Radnor townships.

Many other eruptive rocks, in the form both of dykes and of large bosses, occur in the so-called Laurentian area, in the region south and west of here, being largely developed in Chester county. These rocks are now being studied microscopically by the author, who finds many of them to be of high interest and capable of throwing much light on the difficult geology of the region. The author has discovered an immense area of eruptive garnet-bearing acid norite, with included dykes of diorite, diabase, gabbro, trap-granulite, etc., and he has observed highly interesting effects of pressure, stretching and endomorphic changes. These will be described in a subsequent paper. They are mentioned here merely to state that these eruptive rocks have no possible connection with the much later dyke which forms the subject of this paper.

In Chester county the presence of trap along the southern border of the South Valley hill in connection with serpentine, was briefly noted by Rogers,* and Dr. P. Frazer in his report on Chester county† has mentioned a few isolated occurrences here and there, without, however, noting them on the map. The only portion of the dyke placed upon his map is in Easttown township, where, however, its line is not correctly represented.

An interesting feature of the great dyke in Chester county, are a number of small "jogs," which continually displace the dyke short distances to the northward. They are probably due to faults, since the same peculiar structure is noticeable in the dykes of serpentine in the same region.

Two such jogs are indicated in Easttown township; one of them, half a mile west of Devon Inn, the other somewhat more than a mile south-east of Paoli. The dyke ends south-west of Devon Inn, but appears again farther north on the road leading south from Reeseville, just south of an exposure of serpentine. It now runs south-westerly to the Sugartown road, at a point where the road forks southward to Leopard P. O. In this vicinity large boulders, often four to five feet in length, are scattered about on the soil, and are often resonant when struck. Again the trap makes a jog of about half a mile to the north, as though again faulted. Appearing in the north-west corner of Easttown township, on the road leading from Leopard P. O. to Howellville, south of the cross-road to Sugartown, it here divides the hydromica schists on the north side from the hard syenite and hornblende rocks on the south side. The dyke keeps in this geological position between the two formations all the way from

* Geol. of Penna., I, p. 169.

† C4, Second Geol. Survey of Penna., pp.

here to the vicinity of West Chester, and in this part of its course may possibly occupy a line of fault. A series of serpentine outcrops occupy the same position, being sometimes north and sometimes south of the trap dyke, but nearly always adjacent to it, and generally south of it.

The dyke, containing here specks of pyrite, enters Willistown township, south of Paoli, and skirts the north side of the Serpentine belt. South of Malvern, at the northern edge of the Serpentine belt (about a quarter of a mile south of the State road), the dyke is represented by large and numerous boulders, and a much smaller dyke of trap appears near the southern edge of the Serpentine about one-half mile south of the last place. Massive hornblendic rocks lie immediately south of this.

On the Township Line road between Willistown and East Goshen, close to the crossing of the State road, the trap occurs immediately north of the Serpentine ridge.

In East Goshen township it appears where the State road crosses Ridley creek, and continuing thence in a south-westerly direction, still keeping on the north side of the serpentine ridge, is broken by a small "jog" north of Goshenville. The displacement is only a few hundred feet. Small dykes of trap occur both on the north and south sides of the Serpentine ridge, one-half mile north-west from Goshenville. Thence the dyke passes into West Goshen township, crossing the road between East Goshen and West Goshen townships, near the house of J. Patterson, where it forms a prominent ridge, and the trap outcrops in large angular fragments on the roadside. Ancient gneisses lie south of the dyke and hydromica schists a short distance north of it.

In this township (West Goshen), it is clearly shown where crossed by the West Chester branch of the Pennsylvania Railroad, two miles north-east of West Chester. Here again it is on the north side of the serpentine ridge, or, as it is here called, the "Serpentine Barrens." Numerous boulders lie along the railroad, and the decomposed dyke is exposed in the carriage road alongside. It crosses the road leading from West Chester to Lionville, a short distance north of Taylor's run, south of the cemetery. Further west it appears in East Bradford township, one-eighth of a mile north of an outcrop of limestone, and is well shown where crossed by a branch of the Black Horse run. It was traced continuously by its boulders to the west branch of the Brandywine creek, at Copesville, on the Strasburg road. West of the Brandywine, where crossing the road, it forms rounded boulders, often perfectly oval in shape as though rounded by water action. These atmospheric boulders, produced by concentric weathering, might readily be mistaken for water-worn cobble-stones.

In West Bradford township, the dyke keeps south of the Strasburg road, and was noted when crossing each road. It passes a short distance south of Marshalton, and thence reaches the west branch of the Brandywine creek, one-half mile north-west of Trimbleville. Along its course one frequently sees walls, and even barns and houses built of the trap. The old Black Horse Tavern on the Strasburg road is built of it.

Immediately south of Marshalton, from which place north-eastward for nine miles the dyke has been perfectly straight and continuous, there is a slight bend, or perhaps a small jog in the dyke, as it bends slightly to the south. It is readily traced on all the roads in this vicinity.

In Newlin township the dyke is again associated with a belt of serpentine. Beginning just north-west of North Brook Station on the Wilmington and Reading Railroad, it runs into a serpentine belt, a mile or more in length, which lies north-east and south-west, and which is famous by reason of valuable corundum mines on its northern flank. The dyke apparently cuts through the center of the serpentine ridge. An altered granitic rock adjoins the serpentine, and contains a large number of interesting minerals associated with corundum. The latter occurs both massive and in crystals, and in masses more or less altered into damourite, etc.,* and appears to be of contemporaneous origin with the serpentine.

The trap dyke enters East Marlborough township, one-half mile north-east of Unionville, and passes immediately west of that village, being seen at the fork of the roads, under the bed of a small stream which forms the headwaters of Red Clay creek. Entering west Marlborough township near the village of Upland, large fragments of trap are seen, at the limestone quarries, west of Upland, on the State road. The line crosses the State road at the farm of B. Maule, one mile west of Upland, forming a distinct ridge.

South-west of here it is finely shown where crossing a north and south road one mile north-west of Woodville. It passes under the house of Mrs. Rebecca Levis, half a mile north of the Street road, and for some distance, the road runs along it affording a good exhibition of it. Huge boulders of diabase line the road and are built into the fences and into the walls.

Several small jogs apparently occur in the dyke in the vicinity of Upland. Such jogs are to be expected in a crack in the earth's crust of the length here described. From here, nearly to the Maryland border, however, the dyke appears to be perfectly continuous.

Continuing south-west, the dyke crosses the Pennsylvania and Delaware R. R., close to the crossing of the Street road, and entering London Grove township on the farm of Mifflin J. Baker, it here seems again to divide hornblendic and syenitic older gneisses from the micaceous schists and the quartzites which cover the country to the north-west. It crosses a small creek, the east branch of White Clay creek, south-west of here; is well shown in a north and south road in a wood; passes through the farm of J. Speakman and crosses the Gap and Newport turnpike, one-half mile east of the Londonderry township line.

Passing south-west across a farm once owned by P. McNelly, it reaches the middle branch of White Clay creek near the corner of Londonderry, Penn and London Grove townships.

In the high regions covered by decomposed schists south-west of here,

*See "Corundum, its alterations and associated minerals." F. A. Genth, Proc. Amer. Philos. Soc., Sept. 19, 1873, also Report B. Second Geol. Survey of Penna.

it was traced with difficulty. The rocks are decomposed to a depth of fifty feet or more, and the trap appears only where streams have lowered the surface.

Two local branches of the great dyke appeared in London Grove township. One of these crosses the Street road at Woodville, and the other crosses the same road about a quarter of a mile further west, just west of a small creek and on the west side of an exposure of south dipping mica schist.

These dykes can be traced across a north and south road just west of here. The one is marked by scattered boulders, only. The other and more southern of the two is exposed as a narrow dyke about a yard wide, cutting through a ridge made of decomposed gneiss, on the farm of S. H. Hoopes, one-half mile north east of Chatham P. O.

In Penn township the dyke is marked by scattered boulders only; and the decomposition of the soil is so profound that great care was necessary in following, step by step, the true course of the dyke. It was found to enter the north-eastern corner of the township and, passing a mile and a half north of Jennersville, to go through the farms of J. Vandegrift, S. B. Reese, L. Mendenhall, D. Mackey, Sharlton, Underwood, Myers, Thos. Jackson and Matlock in a continuous south-western line. It passes a quarter of a mile north of Forrestville, where it is shown feebly by a few small boulders on the road side. It crosses the east branch of Big Elk creek, just below the bridge on the road from Jennersville to Russelville, where large fragments occur, some of them ringing like a bell. From here to its fine outcrop west of Lincoln University, it is traced with difficulty, being shown by scattered boulders only.

In Lower Oxford township the dyke is conspicuously shown one mile south-west of Lincoln University, just west of the west branch of the Big Elk creek. It here forms a marked ridge near the house of S. Massey, and is as finely shown as anywhere along this part of its course.

In the diabase at this place there is a soft chloritic mineral in nodules, and a little chalcopyrite.

About one mile south west from here, it is well shown where crossing a north and south road, near the entrance to Mrs. Flemings' farm, half-way between the railroad and the Oxford and Jennersville road.

Fragments five feet or more in length occur here. It runs past the house and reaches the Philadelphia and Baltimore Central R. R., at the meadow adjoining to the west the same house, being somewhat more than a mile west of Oxford station. Crossing the railroad, it enters East Nottingham township and runs through the farms of Mrs. Mercer and W. Pickering, thus just touching the borough of Oxford, though not getting within a mile of the railroad station at Oxford.

All through south-western Chester county the trap is known by the farmers under the name of "Cammels," "Carmels," or "Cammell stone." It is also sometimes called "Iron stone," from the rusty exterior.

"Cammells" appear on the farm of Benjamin Pickering, near Oxford,

and are shown abundantly at the house of James McFall in the adjoining woods, and on the road near a cross-road, at a small creek half a mile east of New Prospect. A large boulder of diabase, five feet long, lies opposite the house of J. Brown (formerly W. G. Hutchinson), and shows the approximate position of the dyke where crossing the main road south of New Prospect.

The trap is again well shown in the meadow of J. K. Newell (formerly Pollock), where crossing North-East creek at the boundaries of West Nottingham and East Nottingham townships. The dyke crosses the creek less than a mile south-east of Nottingham P. O. From here southward, the trap boulders are known as "Niggerheads." In West Nottingham township the dyke once more enters a serpentine region and is here no longer well marked as a separate and distinct dyke. A number of outcrops of diabase occur in this serpentine region, as also a number of other eruptive rocks, including several coarse grained amphibolites and diorites of older geological age. At the chrome mine of Moro Phillips, opposite Pine Grove School-house, there is a small dyke of diabase some five feet wide, which is, perhaps, a branch of the long dyke. Numerous boulders and fragments of diabase occur at the crossing of the Baltimore Central Railroad by the first road north of the Maryland State line. On approaching the State Line Station coarse grained eruptive rocks appear, as also large masses of ligniform anthrophyllite; from here southward, in Maryland, numerous ancient amphibolites, gabbros, etc., occur, probably being of the same age as similar rocks in the vicinity of West Chester.

The dyke, probably, enters Maryland a little west of State Line Station (Penn Mar) on the Baltimore Central Railroad. It has not been traced beyond the borders of Pennsylvania.

Although of remarkable uniformity of texture and composition throughout the whole of its course, this long dyke has, as we have seen, received various local names. While the name "iron-stone" is probably most commonly applied to it, the trap boulders are called "mundocks" in Bucks and Montgomery counties, "camells" in Chester county, and "nigger-heads" on approaching the Maryland border.

A curious bit of history, for the accuracy of which, however, the writer cannot vouch, may be introduced in this connection. It is said that the dyke was used during the late war of the Rebellion by the negro slaves as a guide in their flight northward. Several of the stations on the "Underground Railroad" are stated to have been on or near the line of this dyke. It is said that the negroes were directed to follow these black rocks across fields and through woods until they were led into the hospitable regions of Chester and Bucks counties.

Among the many features connected with this long dyke, are the metalliferous deposits which are due to it. Mention has been made of the pyrite or chalcopyrite sometimes observable to the naked eye, and of the crusts of iron oxide produced as the trap decomposes. The microscope also reveals an abundance of magnetite in the thin section. It is natural there-

fore that, at several points in Chester county, we find that iron ore has been dug adjacent to the dyke.

Throughout the whole line, every feature of the dyke has been remarkably constant, and it is clearly to be regarded as a single dyke, interrupted only by occasional jogs. That these "jogs" are due to contemporaneous faulting will be rendered probable upon a consideration of the great fault in Bucks county, to the description of which we may now proceed.

It has long been surmised that a fault existed immediately south of the long, narrow strip of lower Silurian limestone, which suddenly appears in the midst of the Triassic area of Bucks county. This strip of limestone, extending in a south-west direction from Limeport on the Delaware to a point south-eastward of Doylestown, was briefly referred to by Professor Rogers, and has been mentioned by several geologists since, but never satisfactorily explained. While some thought that it was due to a fault, other geologists (Mr. C. E. Hall, etc.), supposed that it was an island in the Triassic sea, adducing the triassic conglomerate to the north of the limestone as evidence of this theory.

The writer has devoted some time to the study of this interesting region, and, with the able assistance of Mr. S. E. Paschall, of Doylestown, Mr. John S. Ash, of Holicong, and others, has prepared a map of the area, and has been able to trace for a distance of nearly twenty miles an important fault, which has not only thrown up the whole thickness of the Trias, exposing its basal conglomerate, but has brought to the surface its floor of Palæozoic rocks.

The fault has a length of about nineteen and a half miles. Its extreme western limit is near the point where the Neshaminy crosses the line between Bucks and Montgomery counties, about four miles west of Chalfont. (Chalfont is called Whitehallville on the maps.) The line of fault is not visible in Montgomery county, and its western terminus is in close proximity to, and probably in actual contact with a horizon of blackened shales, extending thence in a north-easterly direction, and almost continuously, across Bucks county to the great region of black shales (quarried for curbing stones) about Point Pleasant, on the Delaware river.

The line of fault is marked by abnormal dips, blackened and broken shales, "slickensides," and other evidences of violent disturbance, along its whole length. But its most characteristic feature is the occurrence of a zone of typical "*fault rock*." This very interesting feature is composed of a mass of gray, shaly argillite, so crushed and cracked in every direction, and so baked and changed in character, that it has lost all traces of stratification. This peculiar rock, evidently the result of movement at the time of faulting, is cut by innumerable cleavage planes, crossing one another at every conceivable angle. The small and irregular angular blocks thus produced are very generally covered by slickensides, the result of sliding motion. This *fault-rock* marks the line of fault, when all other indications fail, and has rendered it possible to fix the precise position of the fault from end to end. It fills a zone one hundred feet or more in

width. The writer is not aware that such an extensive exposure of a fault-rock has been previously described. A few yards is usually given as the greatest width to which a fault-rock attains, although similar instances will doubtless be found elsewhere. The great development of this interesting formation along the Bucks County fault, leads to the conclusion that the process of faulting was a sudden event. The immense pressure, which gave rise to the fault, would appear to have been relieved by violent crushing and slipping, perhaps accompanied by earthquakes.

The best exposure of this fault-rock is in the railroad cut immediately east of Chalfont Station, on the Doylestown Branch of the Philadelphia and Reading Railroad—a locality which will well repay a visit. The accompanying sketch very rudely represents the appearance of the fault-rock at this place.



The principal cleavage planes are vertical or with a steep dip, while secondary cleavage planes cut in all directions. These principal cleavage planes are often curved and folded, as is finely illustrated on the Neshaminy creek between Bridge Point and Chalfont. Some interesting photographs were obtained of these contorted cleavage planes.

The fault-rock crosses the Neshaminy creek several times, and the course of that creek from Chalfont to Bridge Point appears to have been determined by the fault. At each place where the fault crosses the winding stream, an easily recognizable ledge of fault-rock appears, as for example near the boundary of New Britain, Doylestown and Warrington townships, or again near where the "State road" crosses the creek, or again west of Bridge Point.

The fault may be followed continuously across Bucks county in a curved line, concave towards the north, from the county line of Montgomery county to the Delaware. It passes through Chalfont and along the Neshaminy to Bridge Point, as already described, being shown in the stream at a point a mile above Godshalk's dam; also half a mile below Godshalk's dam, also just above Castle Valley bridge; also near Spruce hill; again near Bridge Point; thence, less distinctly to the hill below Bennett's corner, where limestone first appears immediately north of the fault, in the road-bed.

At Bushington, half a mile farther East, the limestone is conformably overlaid by Hudson River slates, on which the basal conglomerate of the Trias reposes unconformably. Upper Triassic red shales, dipping north-east, occur south of the line of fault. North-east of Bushington, hills of Potsdam sandstone rise from beneath the limestone to form "Buckingham

mountain," bounding "Buckingham valley" (of limestone) on the south. The fault runs immediately south of this Potsdam sandstone mountain, dividing it sharply from the upper Triassic red shales to the south, from a point near Bushington to the Delaware river below Limeport. All along its route, the characteristic signs of fault-rock may be detected by careful examination.

At "five points," on the "Street road," in the line between Buckingham and Solebury townships, a large mass of coarse-grained trap, known as Solebury mountain, abuts against the south side of the fault, while limestone is quarried north of the fault. Buckingham mountain dies down at this point, and the Potsdam sandstone from here to the river is either absent or represented only by fragments in the soil. The unusual feature of a trap mountain and a sandstone mountain abutting against one another and separated by a fault is exhibited at this point.

The fault passes "Ingham spring" and thence across the hills and through the woods to a point just below Limeport on the river, having been followed by the fragments of characteristic fault-rock lying on the surface. Mr. J. S. Ash, from a study of the position of springs in the vicinity, suggests that the line of fault is a water course, with vent at Ingham spring. This suggestion appears to be corroborated by an unsuccessful attempt recently made (May, 1885) to sink an artesian well a few hundred yards west of Chalfont Station, just south of the line of fault. The drill was sunk 160 feet, the workmen encountering two "boggy" places where black mud and broken stone hindered further operations.

On the New Jersey side of the Delaware, a great outburst of coarse grained diabase has apparently split the fault, since well-marked exposures of fault-rock occur both north and south of the eruptive trap. This trap extends into New Jersey only a mile or so, but beyond it, still extending in a north-east direction, is a horizon either of true fault-rock or of blackened shales, indicating a continuance of the fault. Professor Cook has noted the occurrence of north-east dips in the Triassic slates for many miles in the same direction.

These abnormal north-east dips of the Upper Triassic strata immediately south of the fault, seem to be due to the disturbance which produced the fault. As is well known, the usual dip of these strata is a gentle one to the north west. A large number of localities of abnormal dips were noted in Bucks county throughout the district south of the fault. Some examples may here be given. In Buckingham township, west of Forestville, some ringing, baked shales dip 30° E. 25° N. ; near Worthington's store the dip is $30^{\circ} \pm$ E. 30° N. ; at Carver's mill on Mill creek, three dips were taken successively going east, some ten feet apart, viz: 55° N. 30° E., N. 35° E., N. 40° E., indicating an anticlinal. Farther north-west there are flatter dips, but to the north-east there is again a steep dip to N. 30° E., and just east of Pineville the dip is vertical. Farther west, at Bridge valley on the old York road, some hardened, dark, ringing, fine-grained slaty strata, showing fine ripplemarks, dip 11° S. 70° E. ; fifty feet farther south, the over-

lying red shales dip 10° E. 10° N. ; and twenty feet yet farther south the dip is 10° E. 15° N. Ripplemarks, fossil plants, and traces of coal in thin seams were here observed. Other localities farther west showed dips of 15° E. 10° N., the shales often being dark and resonant when struck. Near Bridge Point, on the south side of the fault, there is a dip of 15° E. 10° S. ; at Bridge Point some hard altered shales dip 30° E. 15° S. ; and some dips to the east were noticed south of Chalfont. Mr. S. E. Paschall reports that eastward dips continue in the strata south of the fault nearly to its western termination. North of the line of fault the normal north-western dip of 10° to 15° is resumed.

As already indicated, a blackening and induration of the triassic shales accompanies the abnormal dips south of the fault. Another zone of blackened shales crosses the county from Point Pleasant in a south-west direction north of the North branch of Neshaminy creek. There is an excellent exposure of this argillite near Point Pleasant, where it is largely developed and is quarried for curbing stone. It rings when struck by a hammer, and has a fine conchoidal fracture. The Indians used it for the manufacture of their stone implements, and traces of an ancient Indian workshop occur at Point Pleasant.

That the induration of these shales is due to the proximity of a trap dyke is a view often maintained, but the facts at command of the writer appear to point to a different explanation. The zones of blackened shales would seem to be coincident with lines of pressure and disturbance. Can it be that pressure alone would suffice to produce the change?

The fault and its accompanying phenomena having now been described, we may briefly consider the Palæozoic strata which it has elevated, before returning to the trap dyke displaced by it. A section across Buckingham valley, at its central point near Holicong, would show the following succession of strata, beginning at the fault: (1) Potsdam sandstone, forming Buckingham mountain, being identical with the Potsdam sandstone of the North Valley hill of Chester county, and dipping steeply N. W. ; (2) Magnesian limestone or calciferous sandrock (Cambrian), dipping steeply N. W., conformable with the Potsdam, and corresponding with the limestone on the northern side of Chester valley ; (3) Trenton limestone, slaty and fossiliferous, conformable with the last, and only differing from beds of the same age on the south side of Chester valley in being non-metamorphic. No beds of marble occur as in Chester valley, but on the other hand a number of characteristic Trenton fossils (trilobites, brachiopods and corals) occur in it ; (4) The basal breccia of the Trias lies unconformably on the last, and the junction is finely exposed on the farm of H. Shepherd, at Holicong. It is formed of limestone fragments cemented by red shale. It is common on the north side of the Triassic area in Pennsylvania (being identical with the so-called "Potomac marble"), but is rarely observed on the southern edge. The writer has also observed it south of Norristown on the Schuylkill Valley Railroad, where it exhibits a small but beautiful fault ; (5) A narrow stratum of red shale, containing

numerous calamites (*C. arenaceous*), overlies the breccia ; (6) The lower pebbly conglomerate of the Trias follows as a well-marked and definite horizon, which may be traced continuously from the Delaware at Centre bridge, past Spring valley, and south of Doylestown to the fault at Chalfont. It forms a ridge of pebbles and is readily recognized. The same horizon occurs at the southern edge of the Triassic area, extending from Norristown to Trenton ; (7) The long succession of red shales and sandstones which form the bulk of the Triassic strata follow on top of the conglomerate.

Had our section been made at Bushington, the Potsdam sandstone would have been absent, and Hudson River slates would have appeared conformably overlying the limestone, and unconformably overlaid by the Triassic conglomerate. These Hudson River slates are believed by the writer to correspond with the South Valley Hill slates and hydromica schists of Chester county, which latter have there been more highly metamorphosed. There is a striking similarity in their general appearance. From the observed dips of the limestone at the south-western end of Buckingham valley, there appears to exist here an anticlinal, by which the Potsdam sandstone is covered over, and the Hudson River slates swing around the end of the valley until they meet the fault. The fault is clearly a large and important one, of several thousand feet upthrow.

Returning now to the long trap dyke which we have followed from the south side of the Bucks county fault to the State of Maryland, it is interesting to find that at a point on the north side of the fault, nearly five miles west of the abrupt termination of the dyke near Bridge Point, another dyke of identical composition and structure as suddenly appears and extends for twenty miles in an arch, until it is again cut off by the fault. There is every indication that it is of the same age and origin as the long dyke previously described, and that it should be considered as part of it. The trap has the same characteristic weathered surfaces, the same metallic ring when struck, it forms the same narrow and often inconspicuous dyke, and hand specimens from the two dykes cannot be distinguished from one another, macroscopically or microscopically.

Starting north of Chalfont, between Pine run and the North branch of Neshaminy creek, in New Britain township, it curves north-eastward so as just to touch the corner of Doylestown and New Britain townships. It passes through the village of Iron Hill, so named on account of the numerous boulders of ringing trap which cover the hill. The dyke is here wider and more prominent than at any other place along this section. It passes thence about half a mile south-east of Gurden Glen Mills, whence, keeping immediately south of the North branch of the Neshaminy, it passes, one-third of a mile north of Fountainville, into Plumstead township. It is followed past Danborough, where it appears at the fork-roads north of the village ; past Gardenville, crossing the road a quarter of a mile north of the village ; whence, curving towards the east, it enters Solebury township north of Carversville. The next village through which it passes is

Centre Hill, where it is clearly marked by numerous boulders. From here to the "Meeting House," near the fault, it was traced by Judge R. Watson of Doylestown, who reports it to be continuous, and Mr. Paschall states that it abuts against the fault.

This dyke is joined by another one, of entirely different structure, near Gardenville. This latter dyke, composed of a coarse-grained, almost granitic diabase, runs in a straight line from here to Point Pleasant, where it forms a large outburst and is finely exposed on the river bank. This dyke is here much wider and more massive than the long dyke which we have been following, and the diabase is not so hard nor so resonant. The decomposition products are also dissimilar. Yet both are true diabases, differing mainly in their degree of coarseness, and, as the following analyses show, of very similar composition. Dr. F. A. Genth* has analyzed the diabase at Point Pleasant, and Mr. F. A. Genth, Jr., has analyzed that from Gulf Mills, Upper Merion township, Montgomery county. The latter is typical of the diabase of the long dyke. Analysis No. I is of the Point Pleasant diabase, No. II of the Gulf Mills diabase.

| | (I) | (II) |
|-----------------------|--------|--------|
| Loss by ignition..... | 0.29 | 2.15 |
| Silicic acid..... | 52.91 | 51.56 |
| Titanic acid..... | 1.03 | 1.63 |
| Phosphoric acid..... | 0.12 | 0.13 |
| Alumina..... | 14.45 | 17.38 |
| Ferric oxide..... | 6.42 | 6.57 |
| Ferrous oxide..... | 4.38 | 3.85 |
| Magnesia..... | 8.34 | 3.42 |
| Lime..... | 9.92 | 10.19 |
| Lithia..... | — | trace. |
| Soda..... | 1.80 | 2.19 |
| Potash..... | 0.57 | 1.46 |
| | <hr/> | <hr/> |
| | 100.23 | 100.53 |

Of similar structure are two other large outbursts of trap which form "Solebury mountain" and "Jericho hill" in Solebury and Upper Makefield townships respectively. These, like the Point Pleasant dyke, appear to have no connection with the long narrow dyke which, with its continuation north of the great fault, forms the subject of this paper. They are composed of a light colored, coarse-grained diabase, crumbling when decomposed, and quite unlike the dense dark rock of the long dyke. These dykes have the curved shape so often seen in the ordinary Triassic dykes, of which those in the Connecticut valley may be taken as types.

While our long dyke represents a simple crack in the earth's crust, the strata on either side being unaltered, these crescentic dykes are accompanied by disturbances in the surrounding strata. Thus the Triassic shales

* Report C⁶, p. 184.